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To: Distribution

From: P. Randall Staver

Subject: Computation of Ablation Profile from Wavefront Data

1. Introduction:

Wavefront Description:

The wavefront error at each point in the pupil is defined as $W(x,y)$, where:

$$W(x,y) = r_{norm} \sum_{n=1}^{N_z} C_n \cdot F_n(\rho, \theta). \quad (1a)$$

In this equation, The coefficients, C_n , and the Zernike function terms, F_n , are dimensionless. Therefore, $W(x,y)$ takes on the same units as r_{norm} . In most cases, the number of terms in the Zernike series, N_z , is equal to 35.

In another form of this same series, the coefficients, B_n have dimensions of microns. In this definition:

$$W(x,y) = \sum_{n=1}^{N_z} B_n \cdot F_n(\rho, \theta), \text{ where } B_n = r_{norm} \cdot C_n. \quad (1b)$$

The coordinate system for W is described in reference 2. Figure 7 from that reference is included as Appendix 1 at the end of this document for clarification. The coordinate system, (x, y, W) , is right handed and defined from the *clinician's* (or *doctor's*) point of view while *facing* the patient. In this system, x is positive in the horizontal direction towards the clinician's right (the patient's left), and y is positive in the upwards direction. The coordinate system is the *same* for both eyes. The wavefront error, $W(x, y)$, is defined at the patient's entrance pupil, in air, for a wave propagating *towards* the patient. The origin, $(0, 0)$ corresponds to the centroid of the pupil. In order for the coordinate system to be right-handed, positive W is towards the clinician, negative W values are towards the patient. Under this definition, a person with *myopia* will have a *negative-going* wavefront error.

The Zernike functions, F_n , are pre-defined in Appendix 2 of this document. Each function is expressed in terms of a radius variable, ρ , and an angle variable, θ . Since θ is defined with respect to the *horizontal* axis The values of ρ and θ are related to x and y according to:

$$x = \rho \cos(\theta), \quad y = \rho \sin(\theta). \quad (2)$$

Please note that this is different than another coordinate system commonly used in optical engineering where θ is defined with respect to the vertical axis.

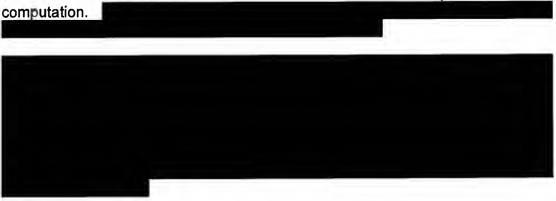
The radius variable, ρ , is calculated from values of x , y , and r_{norm} with:

$$\rho = \frac{\sqrt{x^2 + y^2}}{r_{norm}}, \quad 0 \leq \sqrt{x^2 + y^2} \leq r_{max}. \quad (3)$$

Also please note that r_{max} is the radius corresponding to the *largest* radius recorded in the raw data set, whereas r_{norm} is fixed at 3.5 mm. Within this definition, ρ can vary from 0 to r_{max}/r_{norm} (rather than 0 to 1.0). This definition of ρ has one consequence: *although the coefficients in this definition can be used to reliably predict the wavefront error, they are not necessarily normalized and can not be used to predict the RMS wavefront error (over the whole pupil) using the coefficients alone.*

2. Flow Chart of Computation of Ablation Profile:

A flow chart of the computation of the Laser Ablation Profile is shown in Appendix 5 at the end of this document. It summarizes the 11 steps used in this computation.



Appendix 5: Flow Chart of Computation of Laser Ablation File

